Moncarten



# Small Turbines for Electric Drive

A description with
suggestions and instructions
for their

## INSTALLATION CARE AND OPERATION

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ENGINEER'S REFERENCE BOOK

Please keep this book where your engineer can refer to it readily

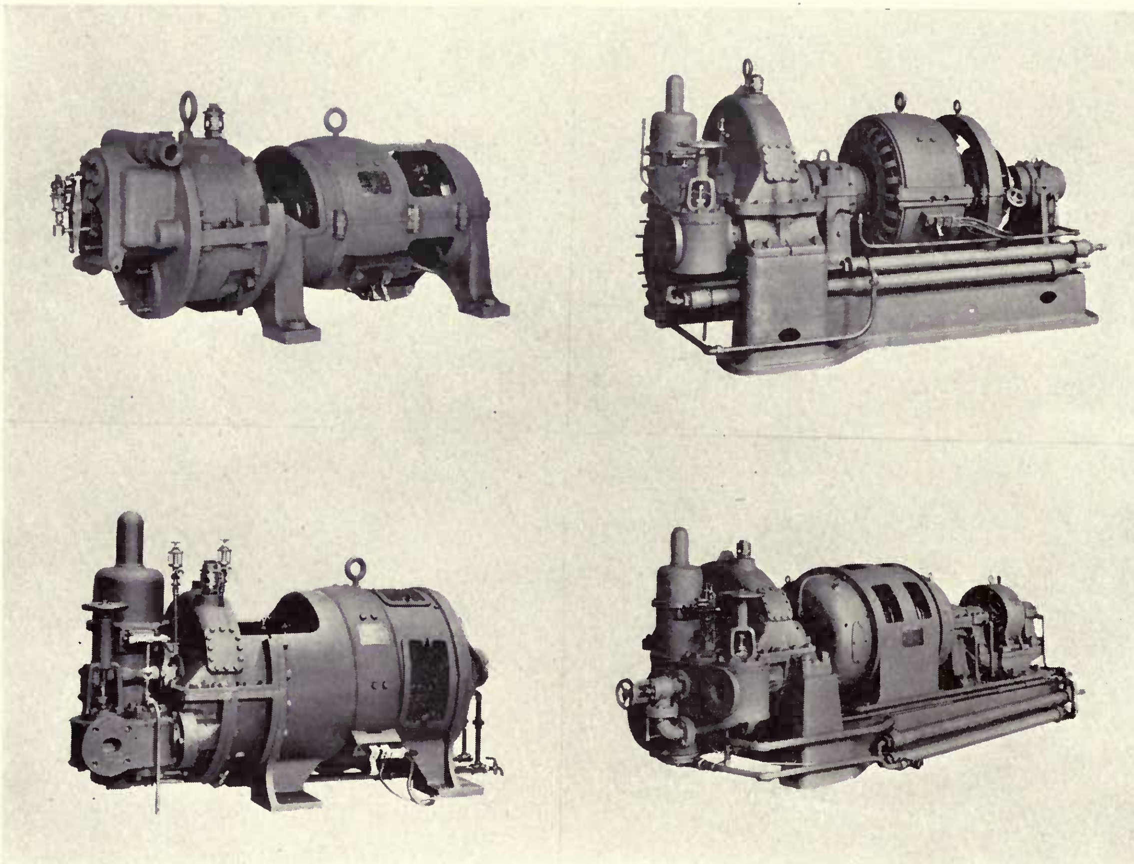
# The Westinghouse Machine Company

# Small Turbines for Electric Drive

A description with
suggestions and instructions
for their

INSTALLATION
CARE AND
OPERATION

EAST PITTSBURG, PA.



10 KW. D. C. Unit
25 KW. D. C. Unit

100 KW. D. C. Unit
150 KW. A. C. Unit

Westinghouse Small Turbo-Generator Sets

# INTRODUCTORY

The following pages describe the small turbines manufactured by The Westinghouse Machine Co., and are intended as a guide for those who have occasion to erect and operate them. The matter herein is confined to a detailed description of the construction together with illustrations. It is believed that a better knowledge of the operation of the machines may be imparted in this way than by a lengthy series of instructions.

The particular type of turbines herein described, is intended for direct connection to small direct current or alternating current generators, in sizes from one to 300 kilowatts. The smaller sizes are designed for non-condensing service only, while the larger units are built for either condensing or non-condensing operation.

Full instructions covering the direct and alternating current generators connected to these turbines may be found in the following publications of The Westinghouse Electric & Mfg. Co.:

D. C. turbo generators, Instruction Book 5107.
A. C. turbo generators, Instruction Book 5024.

## FUNDAMENTAL PRINCIPLES OF SMALL WESTINGHOUSE STEAM TURBINES.

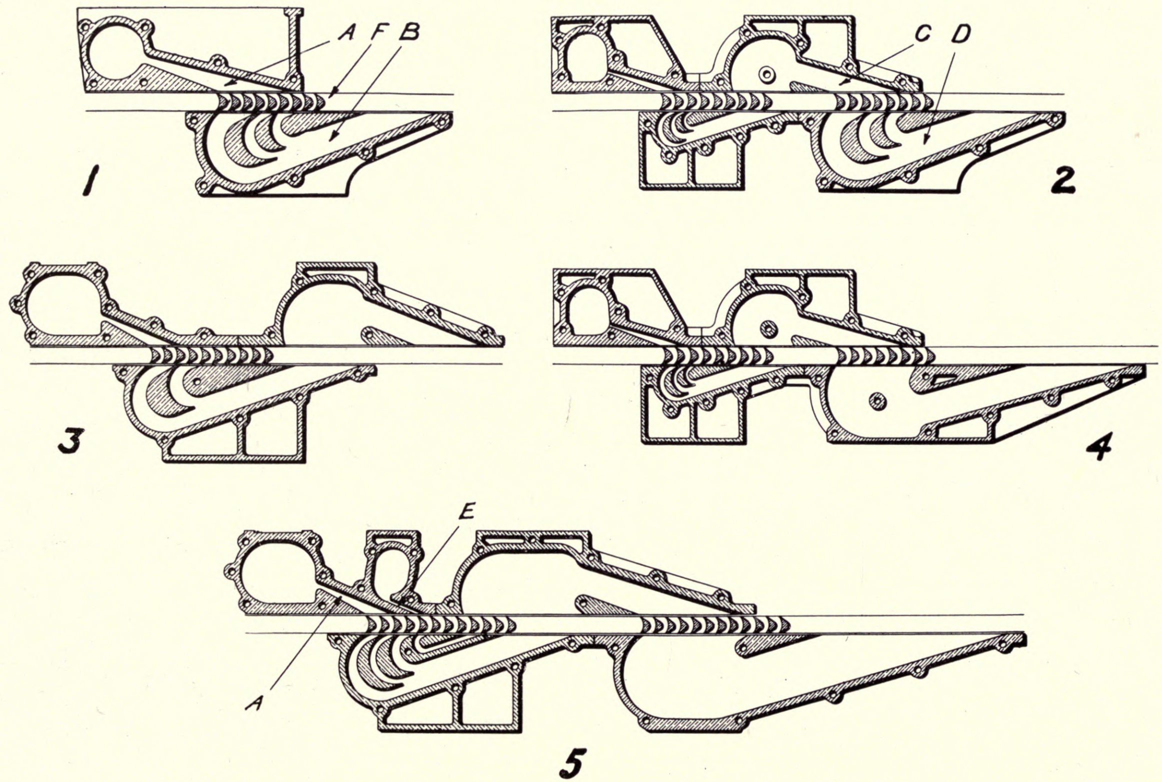
As in all steam turbines, the operation depends upon the expansion of steam in suitably formed nozzles so that the potential energy given up during the expansion causes the velocity of the expanded steam to increase—the velocity at the outlet from the nozzle or nozzles being such that the kinetic energy (velocity energy) is substantially equal to the energy given up during the expansion in the nozzles. After the expansion in the nozzles, and having converted the potential energy in the steam into kinetic energy, means must be provided for converting the energy of motion into mechanical work at the shaft. This may be done in a number of different ways, and the method employed in the small turbines under discussion depends almost wholly upon the operating conditions, though it is also governed partly by the size of the turbine and the shaft speed.

To show more clearly the differences found in the working parts of the smaller turbines, the diagrammatic sketches Figs. 1, 2, 3, 4 and 5 are presented. The principle involved in all of these is the same, differing only in degree of elaboration as higher powers and higher pressure ranges are reached.

The arrangement of Fig. 1 is the simplest, consisting of only the nozzle "A," a single row of rotating blades "F," and the reversing chamber "B," which parts are common to all small turbines. Steam is admitted to the nozzle "A" through the governor valve, and expands to approximately atmospheric pressure, thereby attaining a velocity which is about four times the velocity of the moving blades in Fig. 1. Now since the blades move with about ¼ the velocity of the steam leaving the nozzle "A," the steam after having passed through the moving blades, enters the reversing chamber "B," with approximately half the nozzle velocity.

The reversing chamber "B," as the name suggests, reverses the direction of the steam, and causes it to again impinge on the same row of moving blades, further reducing the velocity of the steam, and thus absorbing the energy remaining after the first passage through the blades.

In the arrangements Figures 2, 3 and 4, the principle of operation is the same as for Fig. 1, except that instead of completing the expansion in the first nozzle, the expansion is carried down only sufficiently far to give the steam the desired velocity, i. e., approximately four times the blade velocity.




FIGS. 1 TO 5

The expansion is then completed in a second nozzle "C" (Fig. 2) after which the steam passes through the blades a third time, enters the reversing chamber "D," passes through the same row of blades a fourth time and thence to the exhaust. This may be regarded as a combination of two of the elementary units shown in Fig. 1, in the same manner as two cylinders of different sizes are put in series to form a compound engine. Thus, by a proper selection of one of these arrangements, the turbine can be adapted to any steam pressure and blade speed.

Fig. 3 shows a nozzle arrangement for a condition intermediary between Figures 1 and 2, in which the steam makes one passage through the blades after passing the second nozzle.

Fig. 4 is a combination occasionally used, in which the element in Fig. 1 is followed by two nozzle elements, each discharging steam once through the blade passages.

Fig. 5 shows the scheme used in some of the larger turbines to permit carrying heavy overloads, or temporary operation with low steam pressure. Steam from the governor valve is admitted to the nozzle "A" same as in Fig. 1, but in addition a secondary hand operated valve admits steam to the nozzle "E," which is also under the control of the governor when in operation. It will be noted that the nozzles "A" and "E" each have an independent reversing chamber, that for the nozzle "E" being located within that for the nozzle "A," thus utilizing the energy in the steam with equal economy at heavy overload, as well as at normal rating.

The overload valve "E" should not be used, however, except when necessary to prevent the speed from falling and lowering the voltage, as then the economy will not be so good at fractional loads.

**General Features of Design.**—All the turbines, excepting the 10 and 15 Kw. sizes, and smaller, are equipped with a vertical geared governor of generous design, having great power, operating at the best speed for efficient and close regulation. An extension of the governor spindle downwards, operates an oil pump of simple design, for supplying the bearings with an ample flood of oil.

Fig. 6 is a typical cross section of a small turbine, and shows also on the end elevation, the automatic stop and governor valves. It will be noted that the rotor carries but a single row of blades, which revolves between the nozzle blocks and reversing chamber, as previously described. These are plainly indicated in the lower portion of the machine.

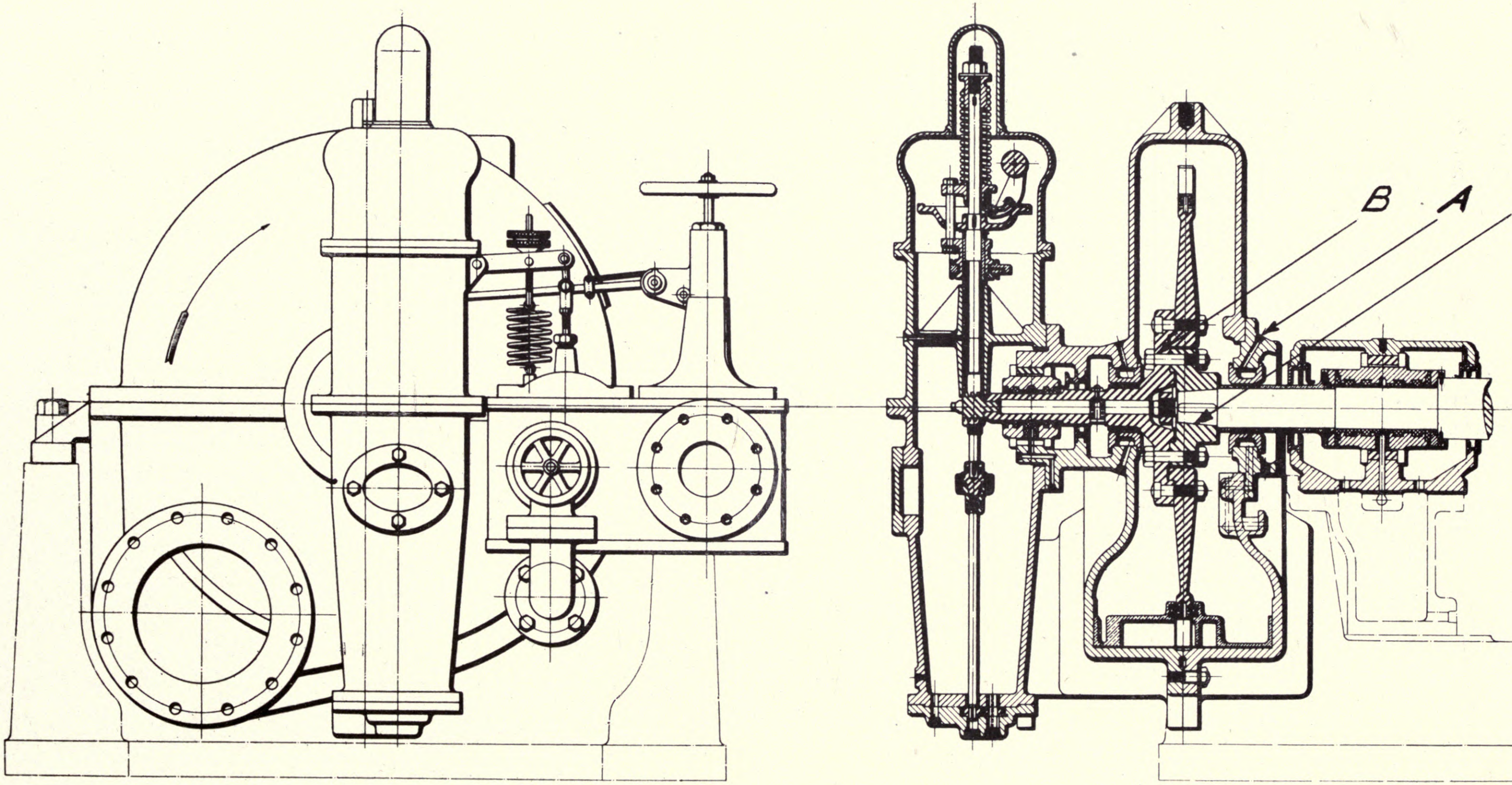



Fig. 6—Typical Section

All the working parts of the turbine are in the lower half of the cylinder or casing, thus making it unnecessary to disconnect the steam and exhaust pipes when the turbine is opened for inspection. Also, it permits the spindle to be removed from the casing without removing the turbine rotor from the shaft. Furthermore the governor (shown in greater detail in Fig. 15) may be removed from the turbine without the necessity of taking it apart, beyond disconnecting the link attached to the governor valve stem. The governor shown in Fig. 6 is driven by means of a worm and wheel, although in some cases bevel gears are used.

The oil pump, which is located under the oil reservoir, is driven by the governor spindle.

This particular design of governor may be removed from the turbine by simply removing the bolts on the horizontal joints and upper half of the vertical joint. However, some governors have the union type coupling and cannot be removed until the union coupling has been disconnected, the latter being accessible through the hand-hole shown in the cross section, Fig. 6.

In the majority of small turbines there are but two bearings, both of which are part of the generator, the turbine rotor being carried on the end of the generator shaft. In some of the larger sizes, three bearings are employed, as also in the case of small turbines for driving alternators.

**Rotor.**—In smaller sizes up to 25 Kw., the turbine rotor is integral with the hub, but in the larger sizes the rotor consists of a hub to which the turbine disc is bolted, the disc being doweled into the hub to insure its running true.

The blades, as will be seen from the cross section of the rotor, are held in place by means of rivets which go through the shanks of the blades inserted in the periphery of the turbine disc.

The hubs of all rotors are fitted on to the shaft with a considerable taper, so that if necessary they can be easily removed by loosening the nut on the shaft and tapping the latter lightly with a babbit hammer. The extension shaft for driving the governor is bolted to the rotor hub and carries the outboard turbine gland sleeve and also the automatic stop, which will later be taken up in detail.

In the case of alternating current units, it is, for electrical reasons practically impossible to split the armature horizontally, and therefore it is necessary to withdraw the revolving field from the armature endwise. For this reason,

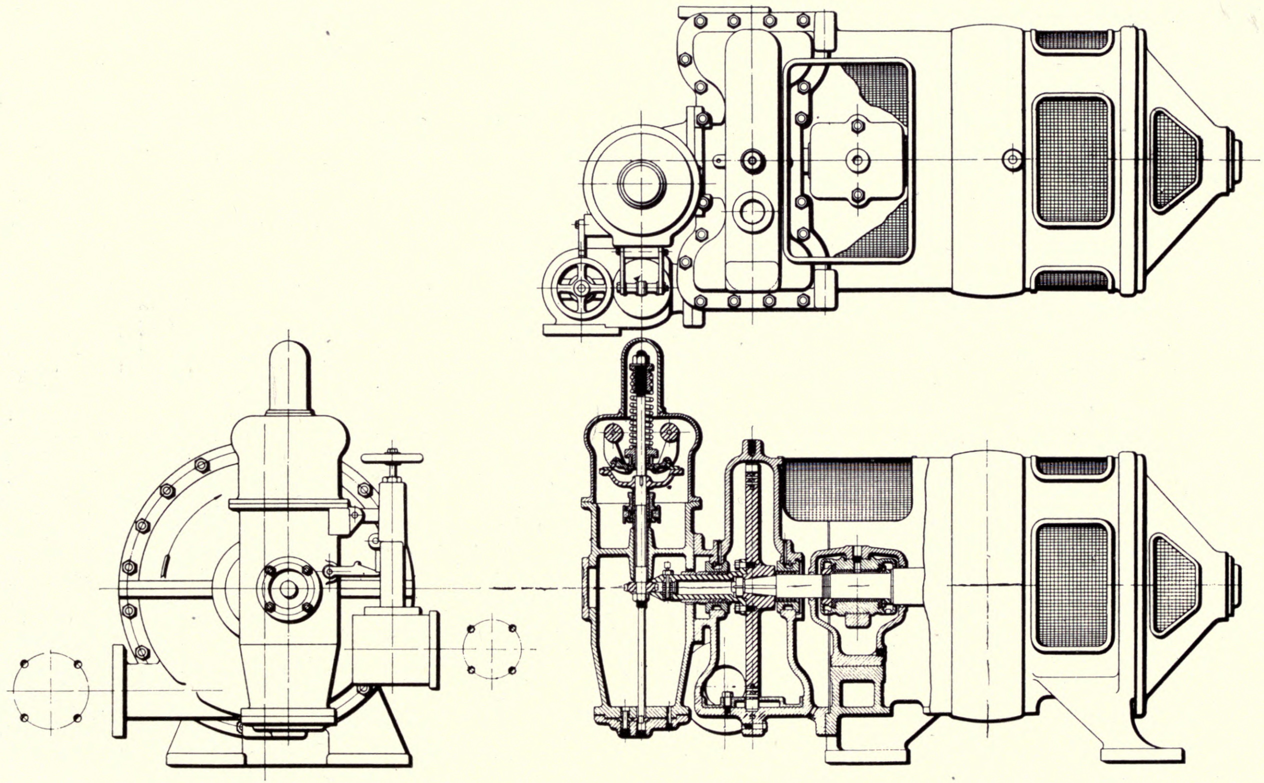


Fig. 7—25 KW. Sectional View

the turbine wheel is doweled and bolted to the governor drive extension shaft, which is in turn doweled and bolted to the hub on the generator shaft. It is necessary therefore, in disassembling the machine, to first remove the gland ring "A" (Fig. 6) and remove the bolts "B," which attach the governor drive extension shaft to the hub "C." The revolving field can then be drawn out through the collector end of the generator. The hub "C" should not be removed from the generator shaft unless necessary in order to remove the gland sleeve "B." It will be evident that these fits should be disturbed as little as possible, so as to maintain the rotor running true.

In assembling the rotor, and all parts of the interior of the turbine, particular care should be taken to ascertain that all wiring and split pins for preventing the loosening of bolts and nuts are in place before the cylinder cover is put on. It is evident that considerable damage might result if a bolt or nut were to loosen and come out while the turbine is in operation.

**Nozzle Blocks, Reversing Chambers and Flexible Packings.** In turbines operating on 125 pounds steam pressure, or less, the nozzle and reversing chamber arrangement shown in Fig. 1 is generally employed, and as previously stated, the entire expansion is completed within the nozzle. There is no tendency for the steam to leak out of the blades or reversing chambers, as the pressure in the latter is the same as in the turbine casing. In the other arrangements, however, as shown in Figs. 2 to 5, as the steam is only partly expanded in the first nozzle, the steam is under greater pressure in the first reversing chamber and following nozzles than in the casing. Therefore, it is evident that since it would be an impossibility to run without clearances between the rotating wheel and nozzle blocks, there would be considerable leakage through the clearances "G" and "F" (Fig. 8), as well as along the space between the periphery of the wheel and the turbine cylinder.

To obviate the leakages which would occur with reasonable running clearances, a packing shown at "D" (Fig. 8) is employed. This consists of one or more brass strips having a lug "C," which are inserted in undercut grooves turned in the flange of the nozzle blocks and reversing chambers. These brass strips, which are made in sections about 3″ long, are pressed against the wheel by small flat springs shown at "E." When first inserted in the machine, the strips are of such a depth that when pressing against the wheel, the lug "C" on

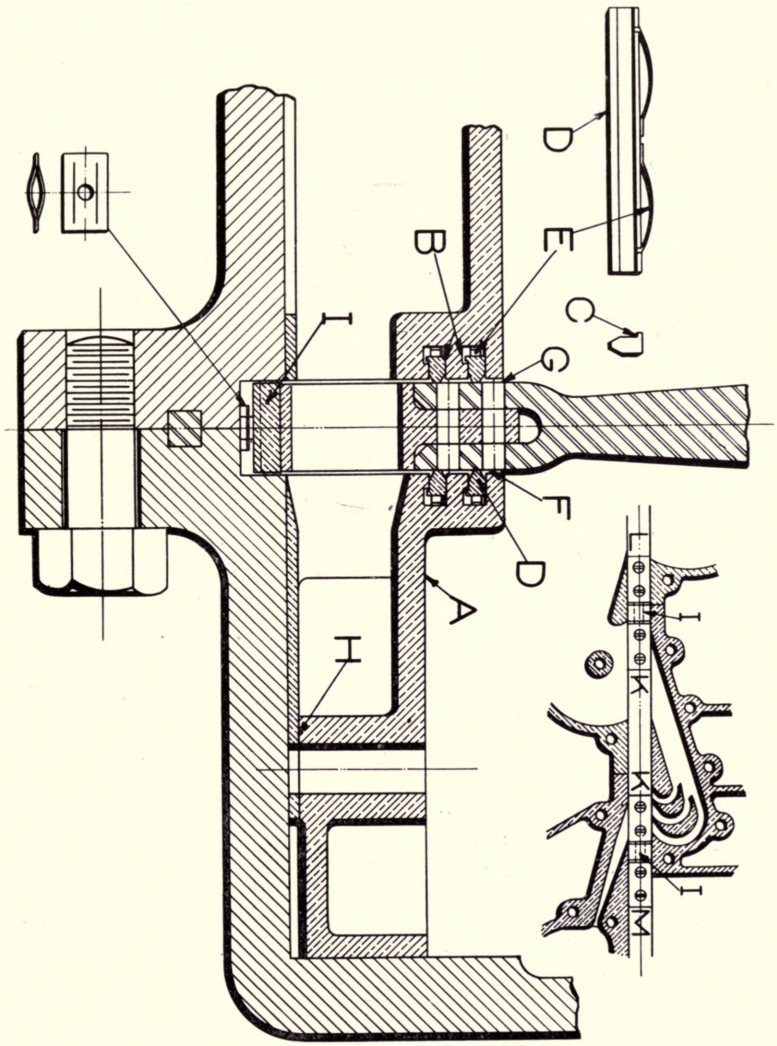



Fig. 8

the strips is a slight amount away from the shoulder "O" of the undercut grooves in the nozzle block and reversing chamber flanges. When the turbine is put in operation, the friction of the brass strips on the turbine rotor wears away the brass strips until the lug "C" of the strips engages with the shoulder "O" of the undercut grooves, which prevents the strips from further wearing upon the turbine rotor—the latter then revolving between the strips without touching them, and yet practically without any clearance. Thus, though the clearance is reduced to practically nothing so far as leakage is concerned, should for any reason an actual displacement of the rotor occur, the packing strips would simply be pushed back against the springs, and wear away without in any way injuring the rotor or turbine.

The leakage which would occur between the periphery of the wheel and cylinder is prevented by packings which work on exactly the same principle, but are made in the form of round or square buttons which press against the periphery of the wheel and are shown at "I" in Fig. 8. These buttons are placed at the beginning and end of each stage in the turbine, as indicated in the small diagrammatic sketch in the upper part of Fig. 8. In the latter, the steam is under pressure in the space "K" and would tend to leak into the spaces "M" and "L" on the other side of the packings "I." The only difference between the button packings and the strip packings is that the former are pressed against the rim of the wheel by small helical springs, in place of the flat springs employed on the circumferential packings.

The packings employed require no attention whatever for normal operation, but if for some reason the turbine rotor has been allowed to move axially, it may be found upon opening the turbine and making an examination that the strips on the one side of the wheel have been worn away so that when the wheel is again centralized, the packing strips on one side or the other may not come in contact with the wheel. If this is found to be the case, the packing strips should be removed and the lug "C" scraped away sufficiently to permit the strips to bear lightly against the rotor, which should be adjusted axially so that a clearance of .020″ to .025″ exists on either side of the rotor, between it and the nozzle blocks. The position of the wheel may be adjusted by means of the thrust bearings as described on page 17, details of which are shown in Figure 13. The position of the wheel, with reference to the nozzles and reversing chambers, may be

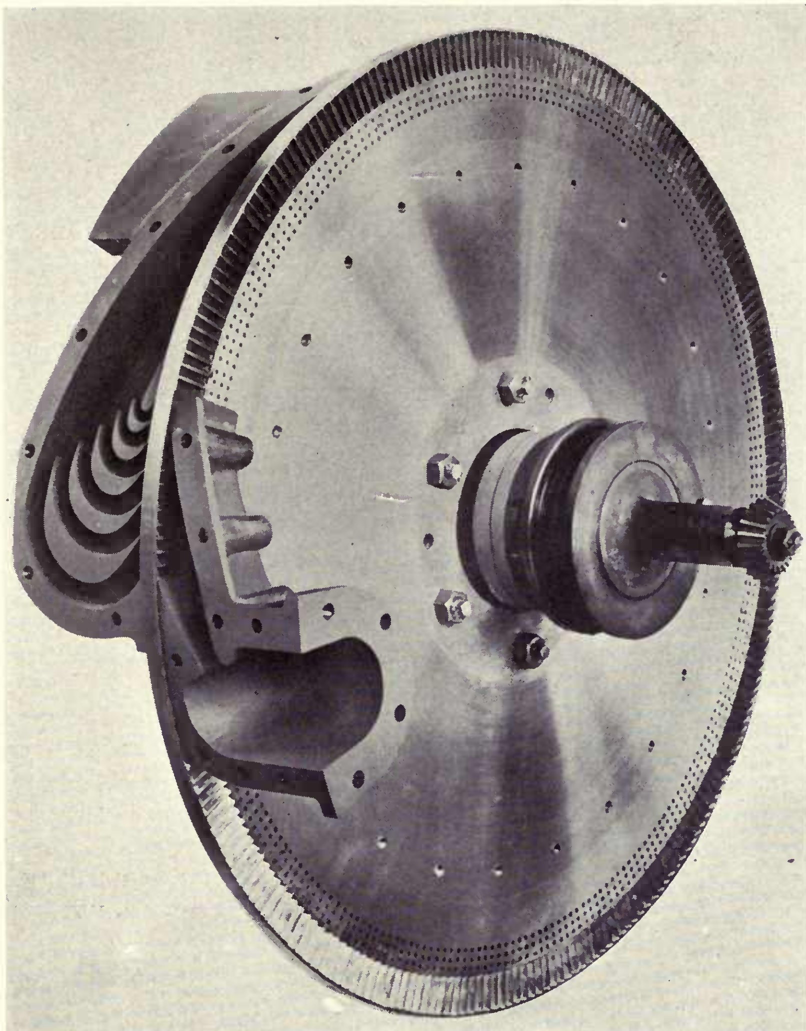


Fig. 9

readily observed through the hand-hole in the cylinder cover. Renewing the packing strips is really a trivial matter.

All nozzle blocks and reversing chambers are very carefully scraped to a steam tight fit before leaving the shop. As any leakage from the nozzles or reversing chambers will impair the steam economy of the turbine, great care should be taken to insure that the surface between the nozzle blocks and the cylinder casing, (as at "H," Figure 8), is a perfectly steam tight joint.

The general disposition of the nozzles and reversing chambers, with reference to the wheel, is shown in Fig. 9.

**Glands.**—In small non-condensing turbines, leakage of steam from the turbine cylinders through the openings through which the shaft passes, is prevented by simple forms of glands shown in detail in Figure 10. As will be noted, the gland consists simply of a number of special bronze snap rings fitted into a cast iron sleeve shrunk on the turbine shaft, and the gland bushing fitted to the turbine cylinder with a steam tight joint, within which the snap rings are fitted. The bushing "G" (Fig. 10) is shown in detail. The one point to be noted is the pocket "A," which supplies oil to the space between the first and second snap rings, through the hole "B." Any steam leaking past the first and second snap rings is free to escape to atmosphere through the hole "C," connecting with the space "E."

A passage "H" is also shown, which connects to a small sight feed oil lubricator, and also a drain passage "I," which should be connected to the sewer or any other convenient point outside the engine room. As the pressure within the turbine cylinder will always be greater than that of the atmosphere, there is no chance for the very small amount of oil supplied to the glands to get into the exhaust steam, as the leakage is always outwards. To prevent a small amount of condensation which might leak past the outer snap ring, from being thrown into the engine room, or being drawn into the generator bearing, a guard "J" is fitted, which effectually prevents the escape of this water, which is collected and taken to a convenient point through the drain "K."

Care should be observed that the piping is arranged in accordance with the foregoing, and that the rings are free and have a side or axial clearance of about .0015″ or .002″ in the grooves, and that they are circular and fit inside of the gland ring "G" snugly and uniformly all around, yet they should not grip tightly enough on the inside of the sleeve "G" to prevent

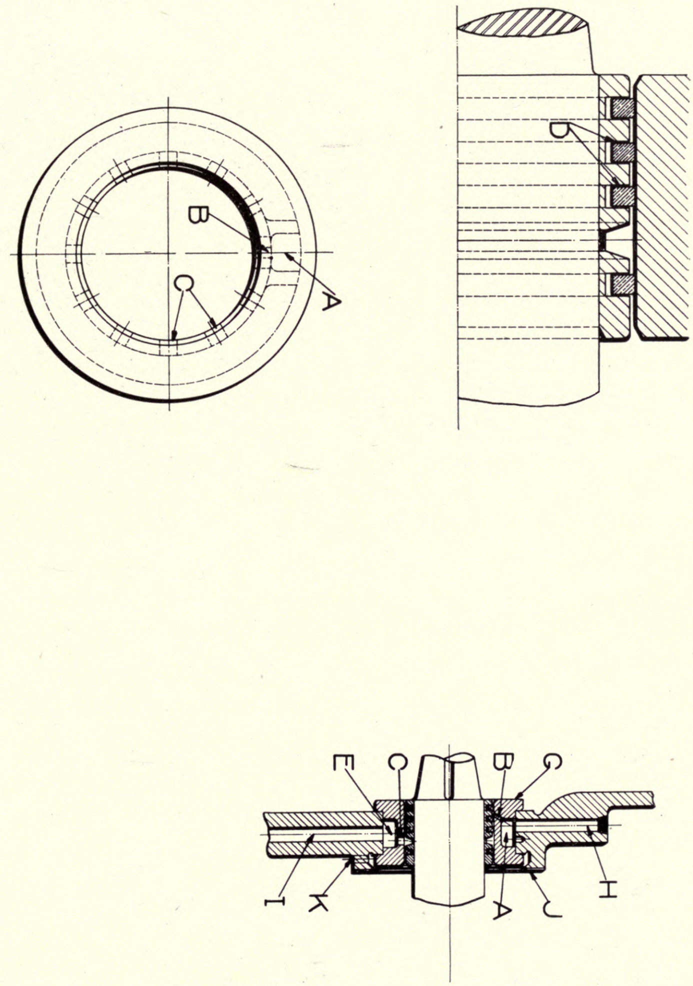



Fig. 10

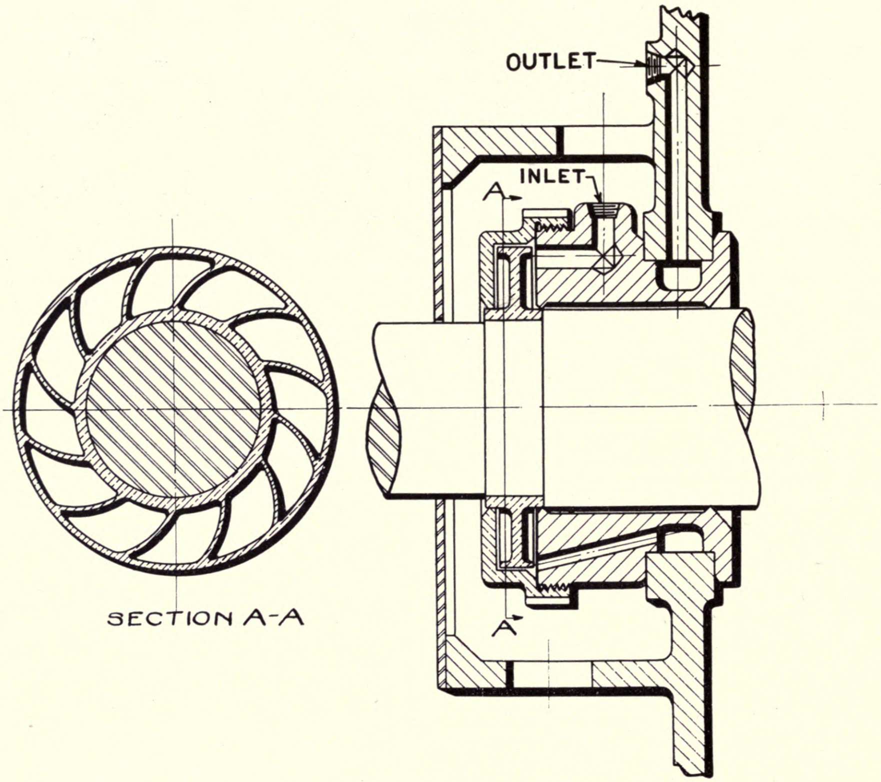



FIG. 11

them from being pushed axially. In operation, the rings remain stationary.

In some of the larger non-condensing turbines, and turbines designed for condensing operation, water glands similar to those used on the larger units are employed. A section of one of these is shown in Fig. 11. The water supplied to the gland inlet connection should be commensurate with the back pressure to be employed—viz., it should be 5 pounds greater than the back pressure. All condensing turbines should have their water glands furnished with water at 5 pounds pressure above atmosphere.

The water glands are provided with a water outlet connection as shown, which should remain closed when the turbine is operating condensing. When operating with back pressure, the valve should permit a small amount of water to escape from the glands, so as to provide a slight circulation through the glands—thus maintaining the temperature below that of evaporation. Otherwise, the water would boil and the steam formed would pass into the engine room.

The most common method of furnishing water of requisite pressure is to connect the oil cooler with a source of water supply, afterwards discharging this water into an elevated overflow at the requisite height above the axis of the turbine to give the proper pressure—the pipe leading to the overflow being provided with a connection to the glands. The provision of an elevated tank, furnished with a ball float is an alternative to be considered.

**Bearings.**—All bearings used on these machines are of the split babbitted type, oil being supplied from the oiling system to be described later, though in some cases the bearings are ring oiled, or have ring oiling in addition to forced lubrication.

The design of a bearing is shown in Fig. 12. The four keys in the center, located above, below and at the sides, have liners beneath them, the manipulation of which permits ready adjustment of the rotor up and down and sideways, with reference to the stationary elements. The inboard generator bearing also serves for adjusting the axial clearances of the rotor, and it is by means of this that the position of the turbine rotor with respect to the nozzle blocks and reversing chambers is determined. The thrust bearing journal and means of adjustment is shown in detail in Fig. 13. The thrust collars "B" and "C" are provided, having a hollow pocket on one side in which split liners are inserted, shown at

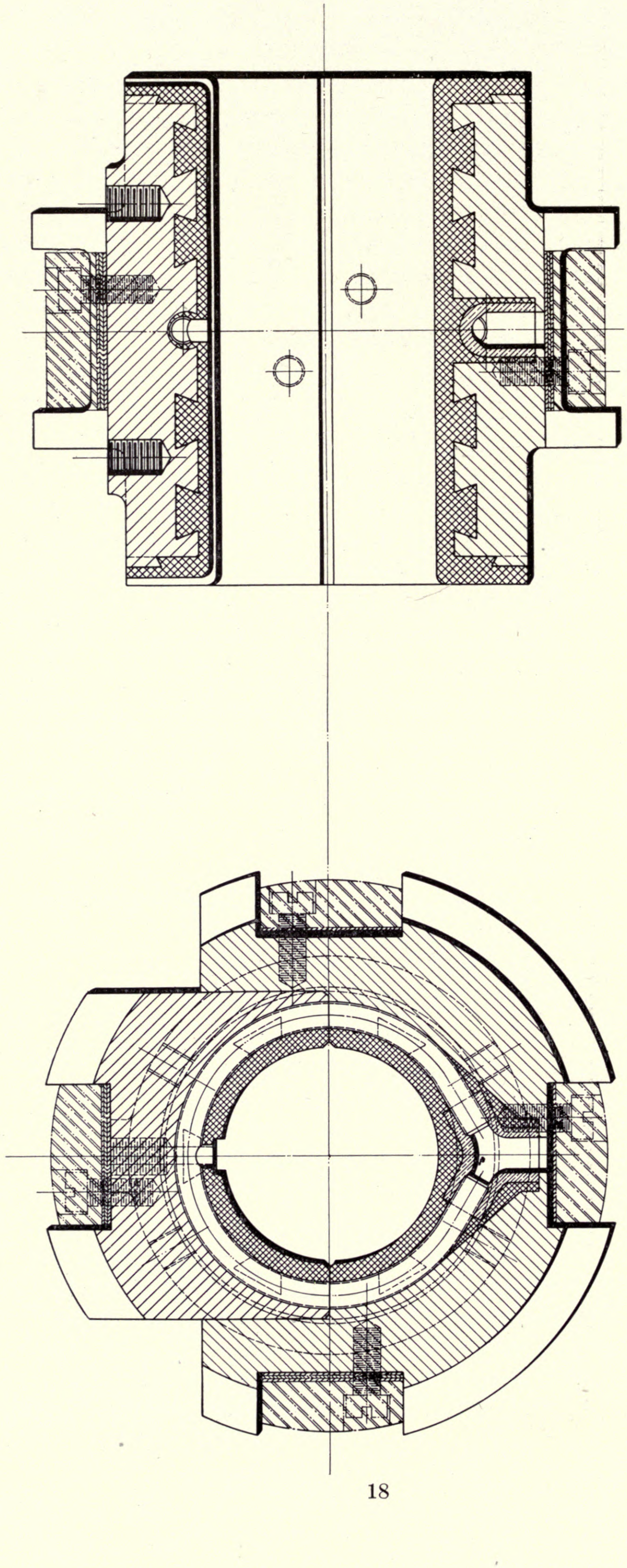


Fig. 12

"D" and "E." The distance between "B" and "C" is kept constant and the axial position of the shaft is determined by shifting liners from one end to the other. Thus, when the clearances have once been determined, if the turbine receives proper attention, and if a proper quality of oil is employed, re-adjustment should be unnecessary for an indefinite period. To insure satisfactory running of the bearings, the radial clearance allowed should be about .005″ or .006″, which is also about the proper clearance axially.

It must be understood that in reality, the thrust bearing does not have to take any end thrust, as the pressure on either side of the revolving element of the turbine is the same. The sole purpose of the thrust bearing is to definitely maintain the axial position of the rotor.

In regard to bearings, it may be remarked for the benefit of those not familiar with the operation of high speed machinery that turbine bearings are operated at higher temperatures than those of reciprocating engines, and should a bearing feel disagreeably warm to the hand, it need cause no anxiety to the operator. The bearings may be operated satisfactorily for years, at a temperature of 150 or 160 degrees F., without experiencing any trouble.

**Governor and Oil Pump.** As previously explained, with the exception of the governors for the 10 and the 15 Kw. turbines, all are of the vertical shaft type, driven from the turbine shaft either by spur bevel gearing or worm and wheel. Fig. 15 shows detail cross section through one of the vertical shaft governors which is typical of those used on all turbines except that it does not have the coupling between the governor spindle and the oil pump spindle, as shown in Fig. 6.

The principle upon which this governor works is the action of centrifugal force on weights which are counter-balanced by means of the helical spring. The governor weights, proper, are small steel cylinders, riveted between the two governor weight arms made of sheet steel. At the lower end of the governor weight arms, and riveted between them are the governor arm blocks which carry the governor fulcrum knife edge and governor weight knife edge blocks. The latter are locked into the governor arm block and are held from lateral movement by the governor weight arms.

Attached to the governor spindle is the governor weight disc, upon which are mounted the governor weight disc fulcrum blocks, which take the thrust of the governor weights. Above the governor weight disc is mounted the governor spring sleeve, which is loose on the governor spindle. This

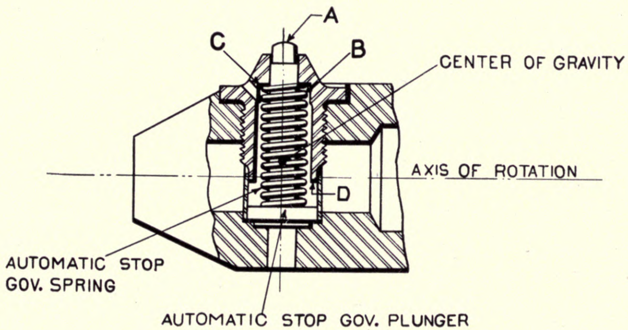

A
C
B
CENTER OF GRAVITY
AXIS OF ROTATION
D
AUTOMATIC STOP
GOV. SPRING
AUTOMATIC STOP GOV. PLUNGER

Fig. 14

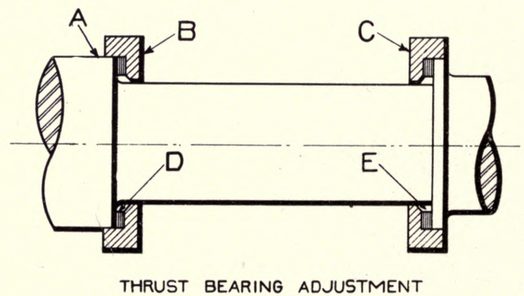

A
B
C
D
E
THRUST BEARING ADJUSTMENT

Fig. 13

sleeve transmits the pressure from the governor knife edges to the governor spring, and is connected by two governor spring sleeve bolts to the governor sleeve, which is free to move up and down, and revolve upon the governor spindle bushing.

The motion transmitted to the governor sleeve is imparted to the governor clutch carrying the trunnion to which the governor clutch levers are attached, and through which the motion of the governor weights is transmitted to the governor valve, through the governor clutch lever link.

A governor sleeve nut is screwed on the lower portion of the governor sleeve, to take the upward thrust of the governor sleeve upon the governor clutch. This nut is retained in any position in which it is placed, by means of the pin and cotter nut shown in the cross-sectional view.

The adjustment of the governor for determining the speed and regulation of the turbine is obtained by means of the governor adjusting spring nut and governor spring adjusting seat. It will be noted in the section elevation and plan view of the governor that a number of holes are provided in the flange on the governor spindle adjusting nut, and also in the governor spring adjusting nut seat, into which a pin may be screwed and secured by the cotter pin. This permanently fixes any adjustment which has been made, the governor spring adjusting nut seat being held from turning on the governor spindle by means of a pin and keyway.

The lubrication of the various parts of the governor is secured by supplying oil under pressure through the oil hole which admits oil to the space between the governor spindle and upper governor spindle bushings, through ports "A." From the annular space between the governor spindle and spindle bushing, the oil enters ports "B" which communicate with the port "C" and supply oil to the governor sleeve, from which it works its way through the ports "D" and "E," through the trunnions of the governor clutch, and lubricates the governor clutch trunnions. Part of the oil supplied to the ports "B" goes to the thrust bearing under the governor weight disc which carries the thrust due to the weight of the governor and governor spindle. This thrust bearing consists of a number of alternate brass and steel rings which are lubricated from the port "B."

The oil collecting in the lower portion of the upper half of the gear case passes through a port "F," and is led by a pipe over the gears, or worm and gear, keeping the latter flooded with a supply of oil.

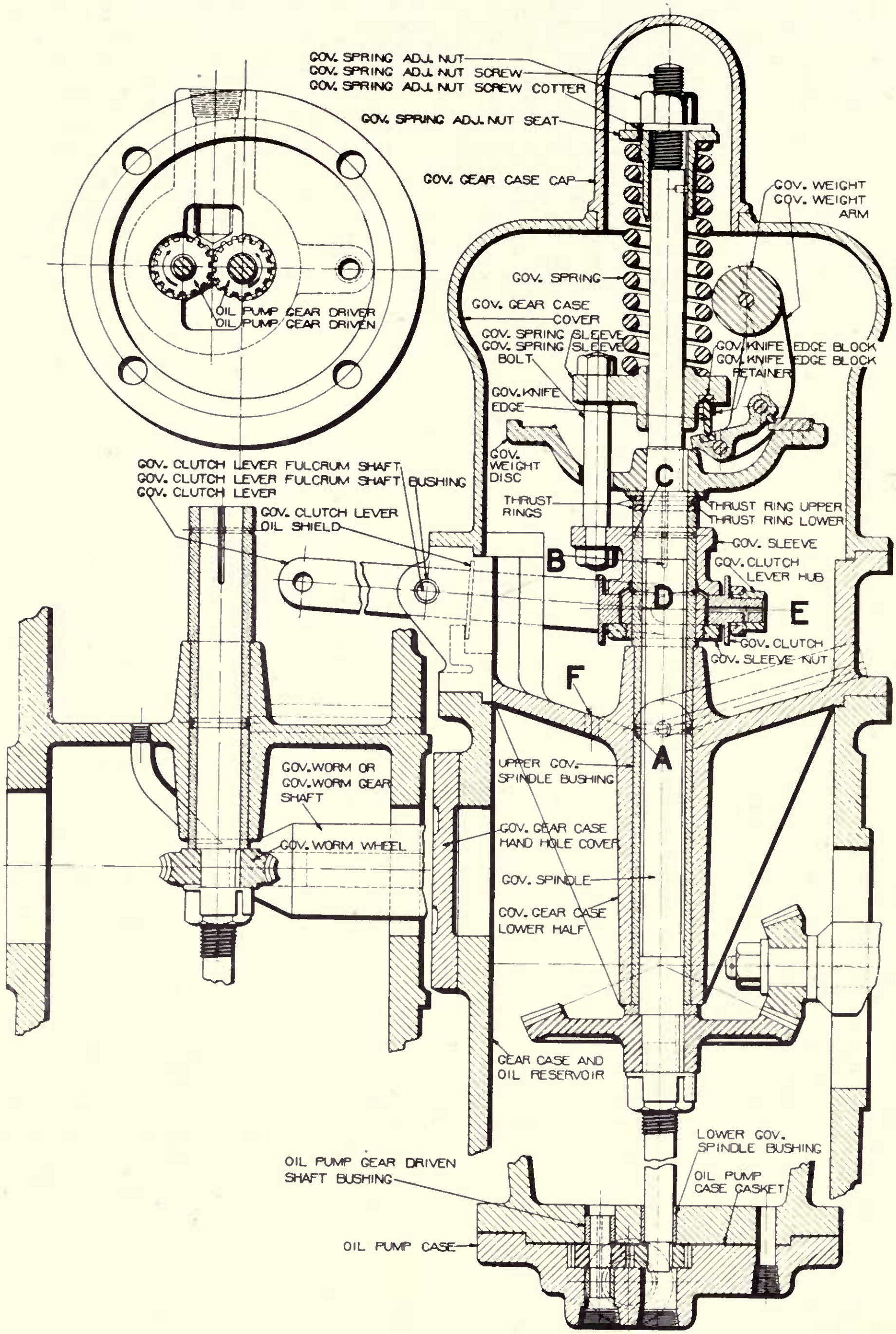

GOV. SPRING ADJ. NUT
GOV. SPRING ADJ. NUT SCREW
GOV. SPRING ADJ. NUT SCREW COTTER
GOV. SPRING ADJ. NUT SEAT
GOV. GEAR CASE CAP
GOV. WEIGHT
GOV. WEIGHT ARM
GOV. SPRING
GOV. GEAR CASE COVER
GOV. SPRING SLEEVE
GOV. SPRING SLEEVE BOLT
GOV. KNIFE EDGE BLOCK
GOV. KNIFE EDGE BLOCK RETAINER
GOV. KNIFE EDGE
GOV. WEIGHT DISC
OIL PUMP GEAR DRIVER
OIL PUMP GEAR DRIVEN
GOV. CLUTCH LEVER FULCRUM SHAFT
GOV. CLUTCH LEVER FULCRUM SHAFT BUSHING
GOV. CLUTCH LEVER
GOV. CLUTCH LEVER OIL SHIELD
C
THRUST RINGS
THRUST RING UPPER
THRUST RING LOWER
GOV. SLEEVE
B
GOV. CLUTCH LEVER HUB
D
E
GOV. CLUTCH
GOV. SLEEVE NUT
F
A
UPPER GOV. SPINDLE BUSHING
GOV. WORM OR GOV. WORM GEAR SHAFT
GOV. WORM WHEEL
GOV. GEAR CASE HAND HOLE COVER
GOV. SPINDLE
GOV. GEAR CASE LOWER HALF
GEAR CASE AND OIL RESERVOIR
LOWER GOV. SPINDLE BUSHING
OIL PUMP GEAR DRIVEN SHAFT BUSHING
OIL PUMP CASE GASKET
OIL PUMP CASE

Fig. 15

A sight feed oiler is fitted to a branch of the oil pipe, supplying the governor with oil, and gives a constant visible indication to the operator, of whether or not the oil pump is working properly. The discharge from this sight feed empties into the upper portion of the governor case, and together with the oil thrown from the governor, lubricates the governor gear as before mentioned. It is important that the oil be continually overflowing at this point.

To obtain close regulation of speed, the scale or degree of compression of the governor spring with a given increase in compressor force upon it, must be properly adjusted or the governor will be over-sensitive, or not sensitive enough. When turbines are shipped from the shop, the governor has been adjusted for desirable speed variations, but should it become necessary for any reason to adjust the regulation, this may be done by tightening or loosening the governor spring adjusting nut. If, upon trying adjustments in various positions, by means of the governor spring adjusting nut, it is found that the governor is unstable and hunts, the number of active coils of the spring should be reduced by screwing the spring farther onto the governor spring adjusting seat, thus increasing the scale of the spring. However, if the governor is not sufficiently sensitive, it is an indication that more coils of the spring are required, and the spring should be unscrewed from the governor spring adjusting seat. When the proper number of active coils have been obtained, accurate adjustment of the speed and regulation can be obtained by changing the position of the governor spindle adjusting nut. To have close regulation, there should be as little lost motion as is consistent with perfect freedom between the valve stem and the governor clutch sleeve.

In adjusting the governor valve, the operator should make sure that the governor valve seats tightly before the governor reaches its extreme outer position. Otherwise, the turbine is likely to go above normal speed and trip the automatic throttle. If it is found that the turbine runs above normal speed and trips the automatic throttle valve, when operating without load on the generator, the governor valve stem should be lengthened by loosening the governor valve stem lock nut and unscrewing the valve stem from the upper governor valve stem end, thus lengthening the valve stem and bringing the valve down to its seat. Too much lenghtening of the valve stem will preclude a full valve opening, preventing the turbine from carrying its proper loads. Assurance should be had that the valve is steam tight, and is properly ground in.

The oil pump is located below the oil reservoir, and consists of two spur gears, one of which is keyed to the lower governor spindle, and the other mounted on an idle shaft running in bronze bushings. The principle of operation is based on the fact that where the gears mesh together, the oil is forced out from between the teeth, whereas around the periphery, the openings are flooded with oil, which is carried around from the inlet to the discharge side. No valves are required in this type of pump, and as it is entirely flooded with oil, no attention should be needed. The clearance between the outer diameter of the teeth and the gear casing should be about .005″ as should also be the clearance between the root of one gear, and the top of the teeth of the other. The vertical clearance between the gears and the casing should be about .005″, which is the thickness of the gasket put between the oil pump case and the bottom of the oil reservoir. In this connection, it must be noted that care must be taken in cutting out this gasket, and also that the portion cut out for the gears and the oil intake and discharge are clean cut, to prevent pieces of gasket from getting into the gears.

An oil gauge is fitted on each oil reservoir to show the amount of oil in the system, and the oil should be carried within about an inch, or inch and a half of the top of the gauge, when the turbine is standing idle.

**Automatic Stop Governor.** A detail cross section through the automatic stop governor is shown in Fig. 14, and in Fig. 16 its connection to the throttle valve. The stop proper is contained within the governor drive extension shaft, and consists of a plunger "A" and spring "B." Adjusting liners are inserted or removed from "C" for changing the speed at which it trips.

As indicated in the diagrammatic sketch, the center of gravity of the plunger is generally located about ⅜″ from the center of rotation, and the scale or strength of the spring is so selected that when the plunger begins to move outwards the centrifugal force, acting on the plunger, increases more rapidly than the pressure of the spring. The travel of the plunger, when it is tripped, is limited by the shoulder "D."

The automatic stop should operate at about 10% or 12% above normal speed, and when it has once been adjusted, should not require adjustment, unless it has been apart for cleaning or inspection. When the automatic stop has been taken apart, either for adjustment or cleaning, care should be taken to put back the cotter pin, which prevents the nut from unscrewing.

Periodically, the automatic stop should be tested to see that it is operating properly, which may be done by pulling up on the governor valve stem, thus permitting the turbine to over speed, and noting the speed at which the automatic stop trips. This should be done several times and the operator should insure himself that the stop trips within 2 or 3% of the same speed several times in succession, to make sure that the stop is not tripped from the slight vibration of the shaft. Also, to insure that the stop is not sticking.

When the automatic stop plunger flies out, it strikes the automatic stop trigger shown in the cross section, Fig. 16, which is attached to the throttle valve latch rod, throwing it in the direction of the arrow and releasing the throttle valve latch, which permits the spring in the automatic throttle valve to close the valve.

**Automatic Throttle Valve and Governor Valve.** A detailed assembly of the automatic stop and governor valve is shown in Fig. 16, from which the construction is easily seen. The steam enters in the space around the steam strainer, which surrounds the automatic stop valve, and prevents any scale or other extraneous material from entering the turbine.

The stop valve is of the balanced type, and operates as follows:—When closed, the throttle valve by-pass valve is on its seat, thus preventing the escape of steam from the space "C" into the space below the valve, which is at atmospheric pressure. Steam, therefore, which leaks between the throttle valve piston and cylinder, on the lower part of the throttle valve yoke, enters the space "C" and holds the valve firmly upon its seat. When the throttle valve hand wheel is turned to open the valve, the throttle valve bypass valve is raised from its seat, permitting the steam in the space "C" above the throttle valve piston to assume the same pressure as below the valve disc. This renders the valve practically balanced, permitting it to be readily moved by further motion of the hand wheel until the throttle valve stem collar comes against the throttle valve stem nut. The throttle valve stem nut is loose, and free to move up and down within the extension of the throttle valve yoke. In the position shown in Fig. 16, the throttle valve is closed and the throttle valve stem nut is in its upper position, being held there by the throttle valve latch which has been mentioned, and remains in the position indicated until released by the tripping of the automatic stop. The throttle valve stem nut is kept from turning by the throttle valve latch, which acts as a dowel. When the throttle valve

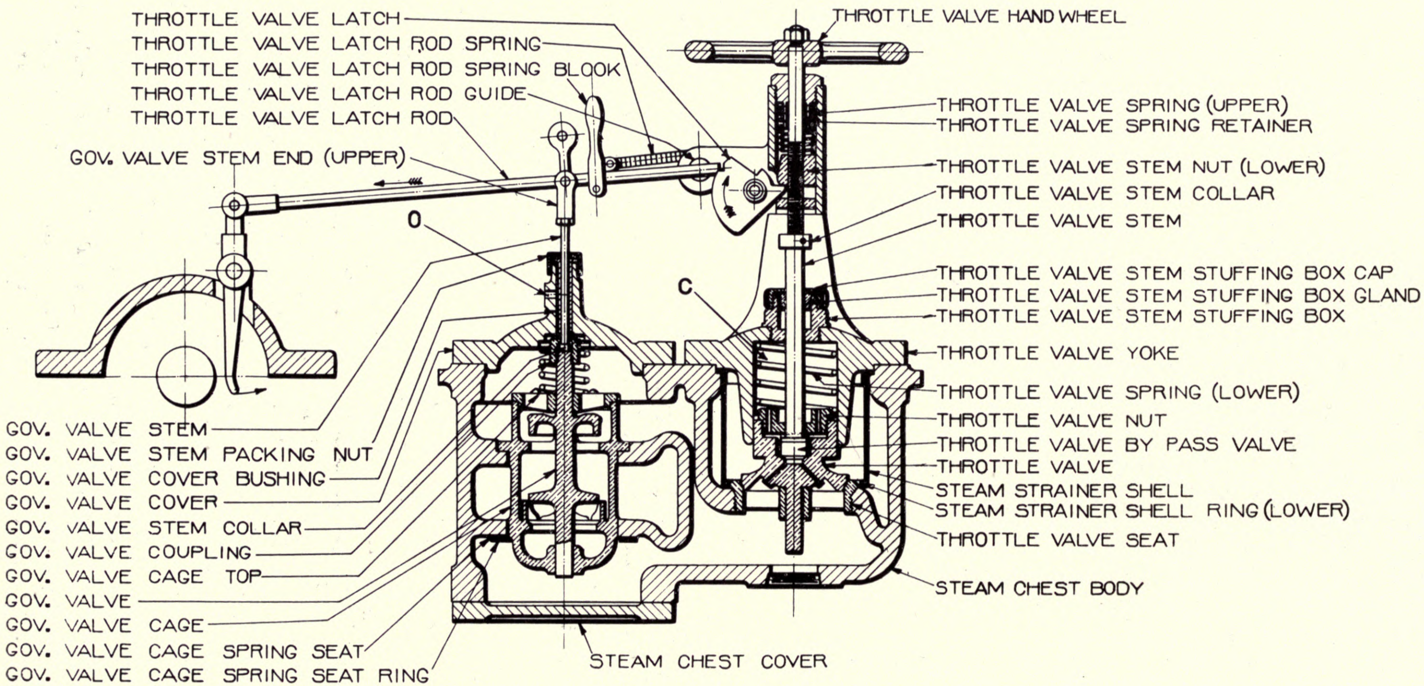

THROTTLE VALVE LATCH
THROTTLE VALVE LATCH ROD SPRING
THROTTLE VALVE LATCH ROD SPRING BLOCK
THROTTLE VALVE LATCH ROD GUIDE
THROTTLE VALVE LATCH ROD
GOV. VALVE STEM END (UPPER)
O
C
THROTTLE VALVE HAND WHEEL
THROTTLE VALVE SPRING (UPPER)
THROTTLE VALVE SPRING RETAINER
THROTTLE VALVE STEM NUT (LOWER)
THROTTLE VALVE STEM COLLAR
THROTTLE VALVE STEM
THROTTLE VALVE STEM STUFFING BOX CAP
THROTTLE VALVE STEM STUFFING BOX GLAND
THROTTLE VALVE STEM STUFFING BOX
THROTTLE VALVE YOKE
THROTTLE VALVE SPRING (LOWER)
THROTTLE VALVE NUT
THROTTLE VALVE BY PASS VALVE
THROTTLE VALVE
STEAM STRAINER SHELL
STEAM STRAINER SHELL RING (LOWER)
THROTTLE VALVE SEAT
STEAM CHEST BODY
GOV. VALVE STEM
GOV. VALVE STEM PACKING NUT
GOV. VALVE COVER BUSHING
GOV. VALVE COVER
GOV. VALVE STEM COLLAR
GOV. VALVE COUPLING
GOV. VALVE CAGE TOP
GOV. VALVE
GOV. VALVE CAGE
GOV. VALVE CAGE SPRING SEAT
GOV. VALVE CAGE SPRING SEAT RING
STEAM CHEST COVER

FIG. 16

latch is released by the tripping of the automatic stop, the pressure of the throttle valve spring on the throttle valve stem nut forces the latter downward, closing the valve, providing the latter has been opened.

From the construction, it will be evident that the throttle cannot be opened after it has been tripped by the automatic stop, until the throttle valve hand wheel has been turned around in the direction required to close the valve, and until the throttle valve stem nut is brought to its upper position, and has caused the throttle valve latch guide rod to engage with the throttle valve latch, and hold it in the position shown in Fig. 16. Furthermore, it will be evident that the automatic releasing of the throttle valve is possible in any position, whether wide open, or only partially open.

The steam after passing through the automatic throttle valve, enters the space above and below the governor valve. The latter is of the double disc poppet construction, thus being entirely balanced for steam pressure. The only force required to move it, is that necessary to overcome a slight friction of the valve stem in the valve stem bushing and valve cage guides. As will be noted, from the cross section, the valve cage is not bolted into the steam chest body but is held on its seat by means of a spring which permits it to expand and contract without warping the valve seats. The lower end of the valve cage is free to expand and contract without resistance, steam tightness being obtained by the valve body being ground into the steam chest, and the governor valve cage spring seat and governor valve cage spring seat ring, shown in the drawing. The valve is so constructed that it has to be moved about 1/32″ before steam begins to pass, thus preventing cutting of the valve and valve seats when steam is being throttled through the valve at light load.

Steam tightness, where the valve passes through the valve bonnet is obtained by a plain bronze bushing and a small soft packing washer, which need not be made very tight, however, as any steam leaking past the bushing will escape through the drain port "O." A more elaborate metallic packing of well known type is employed in the larger sizes.

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